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ABSTRACT

A study was conducted to develop a consensus document that would provide an external perspective of the curriculum in agricultural education that includes agricultural mechanics as a course of study. Data were collected in four phases: solicitation of expert opinion from 53 experts in the field (34 respondents); rating of the opinions; development of consensus through a mailed survey; and data analysis. As a result, 11 statements were agreed upon as critical to an agricultural mechanics program. The experts recommended that the curriculum underscore three broad purposes: developing positive attitudes about safety and quality of work; developing knowledge and comprehension of principles of physical science; and developing useful application skills. Recommendations for teacher preparation were also made. (Contains 19 references and 9 tables.) (KC)

TRANSFORMING AGRICULTURAL MECHANICS CURRICULUM THROUGH EXPERT OPINION TO MODEL TECHNOLOGIES IN FOOD, ENVIRONMENTAL, AND NATURAL RESOURCE SYSTEMS

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Introduction

Kennedy (1993) recognized four fundamental forces working in global change: population growth, impact of technology, environmental damage, and migration. Buriak & Osborne (1996) found that agricultural industry is increasingly technology based. These societal changes have had an impact on the nature of education and work in food, environmental, and natural resource industries.

The adoption of an industrial model during the decades of the 1950's and `60's dramatically changed the nature of agricultural mechanization in the United States. Blacksmiths were converted as mechanics who were transformed as technicians. The need for increasingly specialized knowledge is conspicuous throughout the workplace. Food systems rely on the physical science application of computers, telemetry, and controlling devices for many aspects of production, processing, and distribution. Each transformation substantially altered the nature of the workforce and dramatically increased the knowledge and skills required for global competitiveness. Drucker (1995) predicted that the majority of the future American workforce will rely on technical knowledge coupled with manual skills. Drucker forecasted that "a great deal of knowledge work will require high manual skill and substantial work with one's hands" (p.233).

Opinion leaders have been critical of the present agricultural mechanics curriculum, both in secondary and postsecondary settings. Osborne (1992) and Buriak (1992) concluded that the curriculum must be re-examined and reshaped. Harper, Buriak, & Hilton (1995) advised "... that there is a strong need for leadership, cooperation, and vision for agricultural engineering technology education at all levels" (p.31). Many universities have transformed the agricultural mechanics option into agricultural systems management. Harrison, Schumacher, & Birkenholz (1993) reported declining agricultural engineering technology course requirements for undergraduate teacher education. A paradox has emerged: while there is increasing application of technology in food, environmental and natural resource industries, there is a decreasing emphasis on technology in the secondary agricultural education programs and in the preservice and inservice curriculum for agricultural education teachers.

Purpose and Objectives

The purpose of this inquiry was to develop a consensus document that would provide an external perspective of the curriculum in agricultural education that includes agricultural mechanics as a course of study. The specific objectives were to identify:

1. the purposes of the ideal secondary curriculum that includes agricultural mechanics.
2. the educational experiences necessary to accomplish the desired purposes of the secondary curriculum.
3. how learning experiences can be organized for effective instruction.
4. how the effectiveness of learning experiences can be evaluated.
5. the perceived strengths and limitations of agricultural mechanics as it is now organized.
6. the strategies for the preparation of the secondary teacher in agricultural mechanics.
7. inservice and professional development for teachers in agricultural mechanics.

Limitations

It was recognized that the assumption existed that agricultural mechanics should be a part of the secondary curriculum. Whether it should be or not was not examined in this study. Laird & Kahler (1995), however, using a national sample of secondary agricultural teachers, concluded that agricultural mechanics instruction should be a part of secondary agricultural education curricula.

Methods and Procedures

The inquiry was conducted in four phases, with each phase moving closer to satisfying the seven objectives of the study. Delphi techniques were congruent with the purpose and objectives of the study. The Delphi technique is a method of eliciting and refining group opinions. The procedure is based on iterative and controlled feedback interactions among a jury of identified experts who remain anonymous to each other.

<u>Phase I. (Pre-Data Collection)</u> Fifty-three "friendly critics" of the current agricultural mechanics program were identified from populations that included faculty and administrators from agricultural education, agricultural engineering, colleges of agriculture, and state departments of education. An individually prepared letter invited their expert opinion regarding the content, context, process and interrelationships of agricultural mechanics as a course of study in the agricultural education curriculum. A self-addressed, business reply envelope was included with the letter. The questions used to frame the inquiry were drawn from the basic work of Tyler (1949). Members of The Council Task Force on Agricultural Mechanics also guided the framing process using telephone conference calls. This phase initiated a sustained three-round dialogue among the jury members.

The Rand Corporation found process reliability to be a function of group size. When the number of participants per group was greater than 13, questions of process reliability were satisfactorily answered. Dalkey (1969) determined that mean correlations were greater that 0.80 in such groups. A minimum of 24 experts participated in each round.

Phase II. (Rating the Opinions) The Round 1 instrument was mailed to the jury as a personalized letter describing the purpose of the inquiry and soliciting participation. Round 1 statements from the jury were converged and incorporated into the Round 2 instrument. Round 2 and the following instruments were designed as personalized 5.5" x 8.5" booklets. Round 2 asked the jury to describe their strength of agreement on each statement using a six-point Likert-type scale. An *a priori* decision was made to retain all statements that established an agreement by two-thirds of the jury at levels 5 or 6 (agree–strongly agree). A self-addressed, business reply envelope was included. Summary statistics were calculated for each statement.

Phase III. (Developing Consensus) Frequency distributions were used to extract and refine the Round 2 responses. The statement was retained when two-thirds or more of the jury rated the statement as a 5 or 6 (agree–strongly agree). Round 3 instruments were personalized and mailed with a self-addressed business reply envelope. The jury was instructed to re-evaluate each statement based on information that included their ratings in comparison with the group ratings for each item.

Phase IV. (Analysis of Data) Each statement was analyzed from the Round 3 responses using summary statistics selected to describe consensus. Frequencies were again used to select responses based on a two-thirds majority. Findings were used to develop a consensus document that can provide focus and direction to the curriculum in agricultural mechanics.

An invitation was extended to 53 jury members who constituted the frame of experts. This resulted in an open dialogue with 34 "friendly critics." Round 1 statements from 34 experts were converged and incorporated into the Round 2 instrument. Original language of the experts was retained without attempts to clarify or interpret meaning. Round 2 was mailed to the jury asking them to respond using a six-point Likert-type scale describing their strength of agreement to each statement. Summary statistics were calculated for each statement. Table 1 describes the expert jury, timelines, and statements retained in each round.

Table 1

A Description Of The Expert Jury, Time Lines, And Statements Retained In Each Round.

	Frame	R1	R2	R3	R4
Source of expert jury					
Agricultural education	13	10	10	08	
Agricultural engineering	11	05	02	01	
Deans and Directors	13	09	04	07	
Departments of education	16	10	08	07	
Composite jury	53	34	24	25	
Date mailed		06 Apr	04 May	05 Jun	
Return date requested		21 Apr	19 May	23 Jun	
Number of statements retained					
Purposes			33	16	11
Experiences			37	18	13
Organization			40	17	13
Evaluation			25	16	08
Strengths			32	06	06
Limitations			48	10	10
Teacher preparation			42	10	09
Inservice			25	16	15

Findings

Purposes

Thirty-three composite statements were collected from thirty-four experts as a result of Round 1. Consensus among two-thirds of the jury was achieved for 11 statements after Round 3. The jury recommended that the curriculum should underscore three broad purposes: (1) developing positive attitudes about safety and quality of work, (2) developing knowledge and comprehension of principles that govern physical science, and (3) developing useful application skills. These findings are congruent with those of Harper, Buriak & Hilton (1995) and Laird & Kahler (1995). A composite list of the purposes of the ideal secondary curriculum that emphasizes agricultural mechanics as a course of study is included as Table 2.

Table 2

Purposes Of Secondary Agricultural Mechanics Programs.

The purpose of the ideal secondary curriculum that emphasizes agricultural mechanics is to:

1. develop attention to and consciousness in safety while using technology in agriculture.
2. foster positive workmanship, work habits, time-on-tasks, and decisions about the quality of one's work.
3. instill desirable work habits in students using a variety of "hands-on" activities.
4. acquaint students with principles and competencies related to the application of physical sciences to the problems and opportunities of agriculture.
5. use agriculture, food and biological systems technologies as a context to teach and/or reinforce physical and biological science principles, mathematics and communication skills.
6. develop understanding of the role technology plays in agriculture and the ability to apply basic principles and concepts.
7. promote experiences in using technology in agriculture.
8. complement a comprehensive curriculum in agricultural education.
9. develop understanding that agriculture is broader than production agriculture.
10. develop understandings of basic principles of power and machinery, structures and electrification, agricultural construction, and soil and water conservation and management so principles are used in making decisions in their career for economic, sociological, and environmental advantages.
11. develop skills in a variety of mechanical experiences that the student can use throughout life in either vocational or avocation settings.

Experiences

Round 1 resulted in 37 statements describing the educational experiences necessary to accomplish the desired purposes of the curriculum. Thirteen statements survived the test of consensus through Round 3. Three broad categories of educational experience were recommended: (1) integrating teaching methods that foster knowledge and problem-solving within holistic systems, (2) using project methods that employ current technology to address real-world problems, and (3) facilitating actual work experience. These findings are consistent with those of Harper, Buriak & Hilton (1995) and Rosencrans & Martin (1997). Consensus statements that describe desirable educational experiences is included as Table 3.

Table 3

Educational Experiences Necessary To Accomplish The Purposes Of Secondary Agricultural Mechanics Programs.

Educational experiences necessary to accomplish the desired purpose include:

1. a systems perspective.
2. a strong foundation in the physical sciences.
3. an understanding of the principles of math, science, and technology.
4. a combination of classroom, laboratory, and community-based activities that are very different from the past and closely link with post-secondary and university programs.
5. integrated classroom and laboratory activities, stressing scientific principles and practical skills.
6. lecture, laboratory, simulations, and project application of principles including internships and real world applications.
7. instruction emphasizing safe operation and use.
8. hands-on activities by the student in the laboratory to perfect basis skills.
9. technical information linked with hands-on experiences in classroom setting in relationship to the "real" world.
10. opportunities to work on real problems using real and current tools and equipment.
11. development and/or retrofitted shops (laboratories) that emphasize new technology.
12. on-the-job experiences with real-world application.
13. opportunities for actual work experiences.

Instructional System Design

Forty statements were compiled to describe how the learning experiences should be organized into an effective curriculum. Following the third round analysis, 13 statements met or exceeded *a priori* standards. Four primary categories described the consensus of the jury: (1) insuring all experiences are safe, (2) simultaneously coupling practical examples with theory in experiential learning settings, (3) selecting sequential experiences that apply to broad settings and applications, and (4) organizing spiral experiences that foster technical knowledge, entrepreneurship, and cooperative learning. These findings are consistent with those of Harper, Buriak & Hilton (1995). The consensus statements that describe the instructional system design are included in Table 4.

Table 4

The Elements Of Instructional System Design For Secondary Agricultural Mechanics Programs.

The experiences should be organized as:

1. practical examples used simultaneously with the theory or to explain the theory.
2. classroom and laboratory exercises involving teams and active learning.
3. safety instruction.
4. experiential learning.
5. problem solving and decision making.
6. in-school activities.
7. as coordinated classroom, laboratory and FFA experiences.
8. a sequential curriculum where basic skills in agricultural mechanics that apply to a number of jobs are taught followed by specific job skills that apply to a cluster of jobs.
9. semester-length courses, arranged from simple to complex, and in logical sequence.
10. in-depth specialization in 11th and 12th grade.
11. technology skills needed in specific course; that is, horticulture courses with greenhouses include unit on electrical controls.
12. instruction of sufficient amount in the classroom and laboratory before participating in work experiences away from the school setting.
13. employability and entrepreneurship skills.

Evaluation

To determine if the purposes are met, 25 statements were framed to describe how the experiences should be evaluated. Round 3 resulted in eight statements that met the test of consensus among the jury. The jury validated three broad categories of evaluation: (1) establishing clear and measurable outcomes, (2) insuring evaluation be systemic throughout the curriculum, and (3) using authentic assessment and performance as the primary evidence. These findings are consistent with the recommendations of Finch & Crunkilton (1989), Hughes & Skilbeck (1994), Kirpatrick (1996), and Smith (1994). The consensus statements that frame the evaluation of the secondary agricultural mechanics program are noted in Table 5.

Table 5

The Elements Of Evaluation For Secondary Agricultural Mechanics Programs.

To determine if the purpose is met, the experiences should be evaluated: 1. using clear and measurable outcomes set for the program and for the students. 2. using both summative and formative techniques. 3. to integrate agricultural mechanics as we integrate all other instructional areas. 4. using a variety of evaluation techniques, including performance evaluation. 5. using a variety of techniques with performance measures used to determine student achievement. 6. using team exercises that describe how well team members work together to organize and initiate an assigned project. 7. by performing the task; that is, calibrate a sprayer, calculate the ventilation requirements, calculate the size of a beam, or determine irrigation water requirements. 8. using authentic assessment procedures--actual performance of skills, problem-solving situations, and response to case studies.

Strengths

The jury identified 32 composite statements that described the strengths of the agricultural mechanics program as it is presently organized. After three rounds, the jury agreed upon six strengths. Two categories of strength emerged from the jury: (1) continuing active learning by doing, and (2) developing positive self-esteem among all students, especially under-achievers. Table 6 includes the characteristics that describe the perceived strengths of the secondary agricultural mechanics program.

Table 6

Perceived Strengths Of The Secondary Agricultural Mechanics Programs.

The strength of "agricultural mechanics" as is now organized is that it: 1. is learning by doing. 2. provides hands-on experiences for students. 3. develops and applies practical skills. 4. has "real-world" applications 5. provides opportunities for students to succeed in something that build their self-esteem. 6. reaches students who sometimes have difficulty with "academic" classes in school.

Limitations

Forty-eight statements were included as the initial description of the limitations of agricultural mechanics as it is currently organized. Following Round 3, ten statements describing the limitations were clustered into five sets: (1) poor housekeeping that creates negative image, (2) failing to address higher-level technology skills, (3) using projects that are not appropriate, (4) failing to incorporate electronics and other "high-tech" systems, and (5) teacher background and preparation are often limiting factors. These findings are consistent with those of Harper, Buriak & Hilton (1995). Table 7 includes characteristics that describe the consensus of perceived limitations.

Table 7

Perceived Limitations Of The Secondary Agricultural Mechanics Programs.

The limitations of "agricultural mechanics" as it is now organized is that it:

1. appears to be "low tech" and old fashioned.
2. is not "state of the art."
3. is based on past needs and experiences.
4. is not addressing higher-level technology skills.
5. has equipment that is outdated.
6. has a negative image caused by poor housekeeping.
7. uses projects that are not appropriate for the "new" agricultural industry.
8. may not meet the needs of entire agricultural worker (for example, electronics, controls, and robotics).
9. has poor perception by females.
10. limited by proper background and preparation; that is, prerequisites of the teacher.

Teacher preparation

The jury created 42 statements to describe the preparation needs of secondary teachers. Following Round 3, nine consensus statements were clustered into three categories: (1) problem-solving approaches should be integrated throughout the total curriculum, (2) industry-sponsored programs should be used to develop practical experience, and (3) recognize that agricultural engineering departments that traditionally taught service courses must now respond to a different set of needs and opportunities. These findings are consistent with those of Harrison, Schumacher & Birkenholz but inconsistent with those of Harper, Buriak & Hilton (1995), McGregor & Lawver (1997) and Rosencrans & Martin (1997). The conditions that characterize the preparation needs of teachers of agricultural mechanics are reported as Table 8.

Inservice and professional development

Twenty-five statements represented the initial views of the jury regarding the inservice education needed for teachers. Fifteen statements, the largest total number among the eight categories, met the test of consensus. The jury recommended four broad categories

Table 8

Preparation Needs For Secondary Teachers Of Agricultural Mechanics Programs

The preparation of the secondary teacher should include:

1. agricultural mechanics teacher educators should work within the total teacher education program rather than off doing their own thing.
2. a knowledge (and skill) of the technical subject matter to be taught in high school programs as well as "how to teach" it.
3. more emphasis on safety and maintaining a safe workplace.
4. a focus on technology, science and methodologies to effect a new program direction.
5. problem-solving approaches, as well as other methods to enhance learning.
6. practical experience in using technology in the agricultural area in which they seek certification.
7. industry sponsored seminars in new technology.
8. more emphasis on "new cutting edge mechanized agriculture."
9. a recognition that agricultural engineering departments that traditionally taught "Agricultural Mechanics" courses must now respond to different needs and opportunities.

of inservice and professional development: (1) recognizing a new set of rules for teaching agricultural mechanics, (2) insuring assessment is based on teacher needs, (3) providing access to teaching materials that integrate science, mathematics, and technology using teamwork and modern equipment, and (4) developing strong collaboration among teachers, industry, and university faculty. These findings are consistent with those of Harper, Buriak & Hilton (1995) and the recommendations of Buriak & Osborne (1996) and Rosencrans & Martin (1997). These findings are inconsistent with those of McGregor & Lawver (1997). The characteristics that sustain the inservice strategies for secondary teachers of agricultural mechanics are included in Table 9.

Conclusions and Recommendations

There has been substantial change during the past decade in population growth, the impact of technology, environmental degradation, and increased migration. The rate and effects of change are well documented in education and the workplace (Kanter, 1995; Kennedy, 1993; Senge, 1990). Drucker (1995) concluded that revolutionary changes are shifting our society from generalists to one needing specialized knowledge workers.

There is increasing need and value in understanding and applying new knowledge in work settings. Drucker warned of the challenge to communicate accurately the level of knowledge acquired to those who do not have the same knowledge base. Focusing on core competencies in the physical sciences with contextual applications in food, environmental, and natural resource systems may diminish the paradox of declining technology education in periods of increasing applications of technology in the workplace.

Table 9

Inservice Strategies For Secondary Teachers Of Agricultural Mechanics Programs.

The inservice and professional development for teachers should include:

1. a new paradigm of teaching "agricultural mechanics."
2. efforts in new and expanded areas of instructions.
3. build upon pre-service teacher educator programs to encourage teachers to continue to develop their knowledge (and skills) in "what to teach" and "how to teach."
4. assessment based upon the needs of teachers.
5. ready access to teaching materials that can be easily applied in the classroom.
6. experiences for teachers to integrate science, mathematics, and technology into modern agricultural systems.
7. hands-on teaching of what teachers are expected to teach.
8. teamwork and active learning examples should be among the experiences provided.
9. modern equipment and technology.
10. collaboration among teachers, teacher educators, and industry.
11. mentoring by outstanding teachers in the field.
12. industry cooperation to provide current technology.
13. teachers spending some time in businesses and preparation which relates to content.
14. technical institutes business and industry, and other settings for delivery and contest
15. short courses as appropriate.

The curriculum of the future must foster positive work attitudes, apply concepts and principles of science, and develop useful knowledge and manual skills. Educational experience must be integrated and holistic using the principles of learning organizations to manage both biological and physical science systems. Personal safety is a primary outcome. Experiential learning must simultaneously couple practice with theory. Evaluation must use recognized techniques, but especially make use of authentic assessment and task performance. Developing certification levels, similar to those designed by The Chauncey Group International–Informational Technology Services (1998), is one method to assist with career advancement and in the certification of skills and achievement by the student. Drucker (1995) insisted that "people [must] learn–and preferably early–how to assimilate into their own work-specialized knowledges from other areas and other disciplines" (p.239).

The contemporary curriculum must continue to use active learning methods and build self-esteem among students. Program management must employ realistic experiences through work-based learning, simulation, case studies, and internships. Project methods should resemble the products and processes of the industry. The program must communicate an image that is synchronous with industry.

The teacher is often viewed as a limiting factor in high quality programs. Those charged with the preparation of teachers must develop stronger collaboration with industry, develop problem-solving strategies, and seek courses from non-traditional sources. Traditional departments of agricultural engineering now respond to a different set of clients and are not able to respond as a sole-source of appropriate knowledge and skills in technology and mechanization. Teachers must be active learners that continually re-assess their own needs and access new technology through collaboration.

Kennedy (1993), writing to the larger society, chided that "it remains to be seen, therefore, whether traditional approaches will carry the American people successfully into the twenty-first century–or whether they will pay a high price in assuming that things can stay the same at home while the world outside changes more swiftly than ever before" (p.325). Certainly, the forces of change are at work in the food, environmental, and natural resource industries

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